

GPR APPLICATIONS BY USING UWB PULSE GENERATION

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C E R T I F I C A T E

This is to certify that the thesis entitled **GPR APPLICATIONS BY USING UWB PULSE GENERATION**, submitted by **ABHISEK PRUSTY (110EI0249)** for the award of Bachelor of Technology Degree in **ELECTRONICS and INSTRUMENTATION** Engineering at the National Institute of Technology (NIT), Rourkela is under my supervision.

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ABSTRACT

In this work of my last year venture I speak to a low many-sided quality and ease ultra-wideband (UWB) pulse generator for GPR requisitions. Here I have actualized one UWB pulse generator circuit. The UWB pulse generator is based on the avalanche transistor. This pulse generator circuit provides a Gaussian pulse when it is given by a square wave of an external triggered signal. And further more when it is enacted with 3 kHz square wave, it creates 13ns span Gaussian pulse.

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Chapter 1

Ground Penetrating Radar

1.1 Introduction

Ground Penetrating Radar is a subset of the entire radar frameworks. GPR is additionally regularly called as Surface Penetrating Radar (SPR). These days, GPR is a tremendous and quickly developing engineering and every day the amount of its provisions is as of now developing. Finding pipes and links, civil designing (investigation of extension, seeking voids), security, antiquarianism examination, geophysical overview & confirmation and ice mapping are few illustrations of its requisition. The working rule of GPR is focused around Maxwell's comparison of EM wave spread in inhomogeneous sub-surface media. It couples EM waves in the ground and examines or accepts the backscattered echoes. The EM wave will be back-scattered focused around any electrical parameters differentiates in the ground. The uncommon property of GPR is that it can recognize echoes because of every one of the three sorts of electrical parameters contrasts, i.e. Permeability, conductivity and electric resistivity. This implies that a GPR framework has potential for recognizing and spotting both metallic and non-metallic covered targets focused around the reverberation attributes.

1.2 Applications

Presently-a-days advancement of GPR has been one of proceeding specialized development generally provisions driven, But according to the necessities GPR has gotten all the more requesting, so the gear, different methods and Data handling routines have been created and reLned.

GPR has been used in the following applications:

- " Examinations in Archeological
- " Building condition assessment
- " Bridge deck analysis
- " Borehole inspection
- " Land investigation

- ~ Detection of buried and undergrounded mines
- ~ Forensic investigations
- ~ Geophysical investigations
- ~ Medical imaging
- ~ Pipes and cable detection

1.3 GPR Principle

In nowadays Ground Penetrating Radar (GPR) is turned into a standout amongst the most guaranteeing advances for Close discovery and better identification of covered Anti-Personnel and Anti-tank Landmines, on the grounds that it can catch non-metallic protests in the sub-surface. The working rule of GPR is it sends the Electro-Magnetic waves into the ground and specimens the backscattered Echoes. One of the way of GPR is that echoes could be recognized from every one of the three sorts of electrical parameters contrasts, i.e. this kind of nature shows that the GPR framework has the capacity for looking and recognizing both metallic and non-metallic undergrounded targets. In GPR the reception apparatuses could be checked over the surface near the ground. The EM wave controlled into the ground will backscatter on any electrical parameter irregularity. At that point collector courses of action and specimens the backscattered echoes after gained by beneficiary reception apparatus. FIG 1.1 shows a block diagram of ground penetrating radar system [1]. Fundamentally first and the biggest reverberation are a result of the interface between air and ground and the consequent echoes are because of the impression of the target or because of the vicinity of jumble in the subsurface. A 2d or 3d picture could be handled by the GPR by moving the reception apparatuses on a 1d or 2d framework. Not at all like the metal locator might the GPR be utilized to recognize non-metallic targets, which discovers substantial requisition in AP land mine discover.

Ground Penetrating Radar is classified in 2 types.

- ~ Time Domain GPR
 - Amplitude modulated GPR
 - Carrier free GPR
- ~ Frequency Domain GPR
 - Linear Sweep GPR
 - Stepped Frequency GPR

Time domain GPR is further divided into two categories 1st one is amplitude modulated and 2nd one is carrier free GPR. The principle of time domain GPR is to send a pulse at a particular PRF into the ground and then to record the scattered back echoes. The duration of the pulse is kept for good depth resolution. A pulse along with a carrier frequency is sent by the amplitude modulated GPR. The carrier frequency modulation is done by a square wave envelope. The short pulse duration is achieved using a mono-cycle. The central frequency of the mono-cycle as a range of few MHz to few GHz depending upon the application. The central frequency of mono-cycle is same as the 3db bandwidth of the emitted pulse.

The increase in demand of a higher bandwidth led to a second category of time domain GPR i.e. carrier free GPR. A pulse without carrier is sent by the GPR. The carrier free pulse width as the order of some Pico-second. Any type of pulse can be used by this GPR, but generally a Gaussian pulse is used. The carrier free GPR is also known as UWB GPR.

The second category of GPR system is frequency domain GPR. Which is classified into two types one is linear sweep GPR and another is stepped frequency GPR. In the 1st type frequency modulation of a continuous wave is done with a linear sweep and named as FMCW GPR. The FMCW GPR system transmits continuously a time vary carrier frequency with a help of vco between a given ranges of frequencies. The frequency is stepped in accordance to a saw tooth or triangular function in a certain dwell time. The scattered back signal is received and mixed with the emitted wave. The transmitted and received wave frequency difference is a function of the depth of the target. The poor dynamic range is one of the major disadvantage of FMCW radar. Simultaneous reception and transmission of the signal is done by FMCW. The smaller backscattered signal is hidden by the leakage signal between the antennas. The following drawback has led to the decrease in demand of FMCW for GPR and the demand of step frequency RADAR has increased.

A step frequency GPR steps to a range of frequency with the help of a frequency synthesizer. A carrier wave of higher stability is radiated and mixed with received signal at each frequency with the help of quadrature mixer. The sampling of the I and Q base band signals is done with the help of high precision and low speed AD converter. The comparison between the amplitude and phase of the received and transmitted signal is done at each frequency.

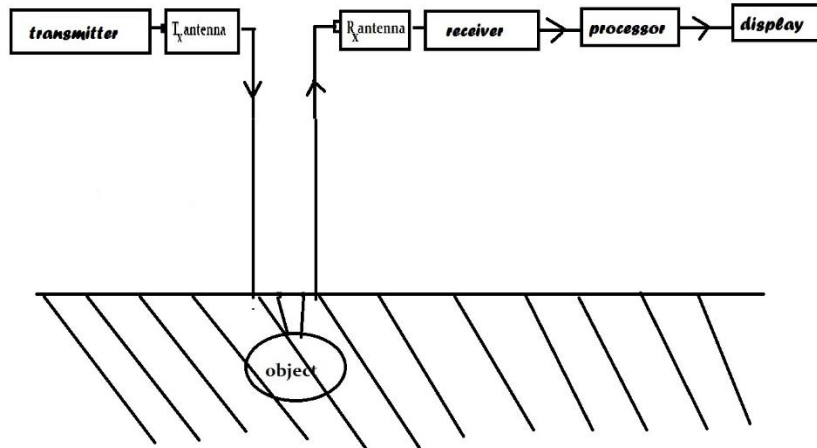


Fig 1.1: Ground Penetrating Radar block diagram. [3]

1.4 Description of a time domain GPR

Along with data processing and display the time domain GPR has three other importance parts i.e. transmitter, timing circuit and receiver. Transmitter and receiver are triggered by the timing circuit.

Short transient pulse with a certain period is generated by the transmitter, thus acting as a pulse generator. The pulse periodicity is known as pulse repetition frequency. The Gaussian and mono-cycle pulse shaped are used in the GPR. Sometimes derivative of a Gaussian pulse, step pulse and other pulse shapes are used.

In order to get large fractional bandwidth, better dynamic range and good noise reduction a sensitive receiver is used. The receiver has 4 main parts i.e. TVG, low noise amplifier, sample and hold circuit and ADC.

The timing circuit has the following functions

1. Triggering the impulse generator
2. Generating timing signal for the sequential sampler
3. Control the timing for TVG

1.5 Goal of the thesis

GPR can be used for both metallic and non-metallic objects in the subsurface. GPR, with a large bandwidth system efficiently detects small targets buried into the air-ground interface. For a better depth resolution and detailed echo a larger bandwidth is required. This need for a larger bandwidth has led to the use of UWB GPR. The range resolution of a radar system is defined as the ability to distinguish between two targets solely by the measurement of their ranges (distance from the radar); usually expressed in terms of the minimum distance by which two targets of equal strength at the same azimuth and elevation angles must be spaced to be separately distinguishable.

In UWB GPR, UWB and ultra-short pulse is transmitted into the ground. one of the critical functions in the UWB GPR is UWB pulse generation. Goal of my thesis is generating UWB pulse using simple circuit elements like transistors, capacitors and resistors.

1.6 Conclusion

GPR is one of the most advanced and promising technology for buried object detection. The range resolution is directly proportional to the bandwidth of the system. The UWB GPR has been developed to meet the larger bandwidth requirement. The major challenges faced by GPR research community are the generation and reception of UWB pulse and to design a reliable UWB GPR system at a releasable cost.

Chapter 2

UWB Pulse Generation

Technology

2.1 Introduction

Pulsed UWB uses pulses with a very short pulse width, usually of the order of nanoseconds or some nanoseconds. This helps in spreading of the radio power signal over a wider bandwidth. This feature provides high time and range resolution, reduced multipath fading, lower power and complexity, high data rates and low probability of unwanted detection. Pulsed UWB transceivers with low cost and low power find large application in wireless communication, biomedical instrumentation, wireless personal and sensor networks and inter-chip communication.

2.2 technique and methods I have approached:

Because of the limitation of the instruments and devices, we chosen UWB pulse generators based on transistors. In this project we have chosen two transistor UWB pulse generators.

First one is based on *normal transistors*, and the second one based on *avalanche transistor*.

2.2.1 Transistor based UWB pulse generator:

The circuit gives the Gaussian pulse when enacted by a square wave [4, 6]. This pulse generator utilizes a basic normal emitter amplifier took after by RC high-pass filter. In this circuit we can tune the pulse width term by differing the incline of the square wave. Beneath Figure indicating that, V1 and V2 voltage level pole be in inverse stage. The two transistors along these lines are individually in an off and on state. By assuming that transistor Tr1 is in "off" state and Tr2 in "on" state, so V1 and V2 are individually low and high, the same transistors determined by the direct, and inverse in stage, edge of the connected square wave indicator, create a Gaussian beat. The focal point of the generator is low-unpredictability, minimal effort, and flexible, so we can utilize this generator within a mixed bag of coordinated circuits UWB balance plans and systems.

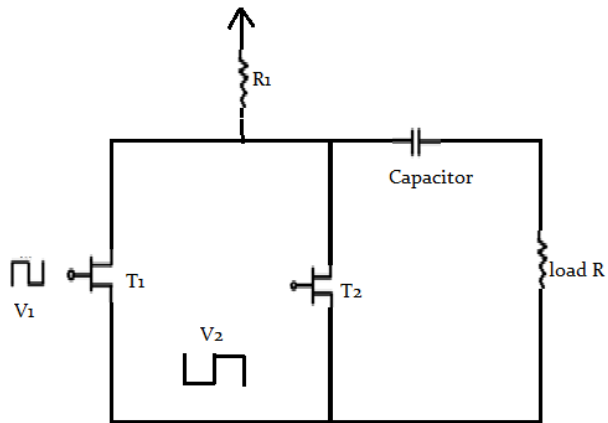


FIG 2.1 BJT based Pulse generator architecture [6]

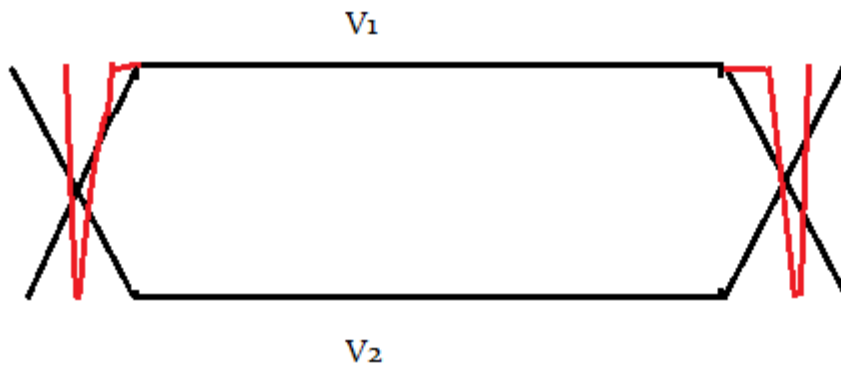


FIG 2.2 Control Signals and generated Gaussian pulse.[6]

2.2.2 Avalanche transistor based UWB pulse generator:

Underneath figure is an essential circuit of avalanche transistor. The static load safety of avalanche transistor is RC . When trigger pulse nearing, the base is zero predispositions and the avalanche transistor works in cutoff region. one more thing it will work on the basis of avalanche effect. [6]

The avalanche transistor has consistently four working regions:

- 1) saturation region,
- 2) linearity region,
- 3) cutoff region
- 4) avalanche region.

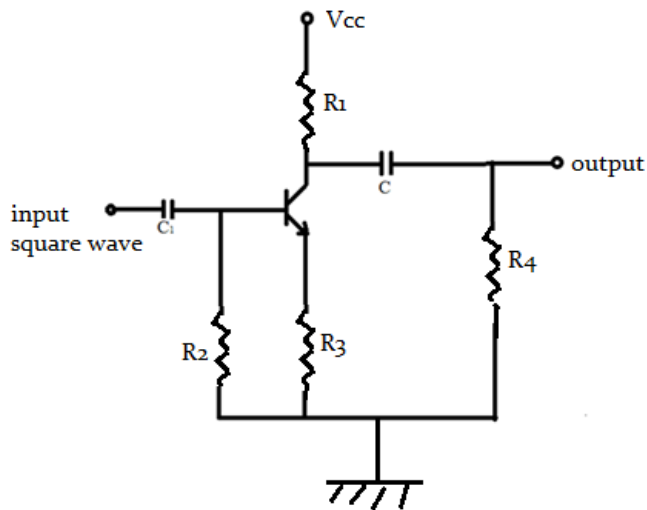


FIG 2.3 Avalanche transistor UWB pulse generator. [6]

2.3 Conclusion:

In view of the restriction of the instruments and gadgets, I picked UWB pulse generators focused around transistors. In this venture we have picked two transistor UWB pulse generators. Initial one is focused around ordinary transistors, and the second one focused around avalanche transistor.

Chapter 3

IMPLEMENTATION OF THE PULSE GENERATOR CIRCUITS

3.1 Introduction

In this work, I actualized one low-intracacy, ease UWB pulse generator circuits. I actualized the the circuit is by utilizing the 2N5551 avalanche transistor, this circuit gives the Gaussian pulse when initiated by a square wave data. This pulse generator utilizes a straightforward common emitter ampliŁer took after by RC high-pass Łter. In this circuit we can tune the pulse width length of time by changing the incline of the square wave.

Anyway this one gave better and obliged yield in light of its avalanche effect.so I recognized just this one. This pulse generator likewise utilizes a basic common emitter ampliŁer took after by RC high-pass Łter. This circuit likewise gives the Gaussian pulse when enacted by a square wave.

3.2 Avalanche transistor based UWB pulse generator

This pulse generator [15, 16] utilizes a straightforward common emitter ampliŁer emulated by RC high-pass Łter to produce UWB pulse. Here we utilized 2N5551 avalanche transistor to produce UWB Gaussian pulse. What's more we utilized R_{cc} is 10 kilo ohm, C_{cc} is 0.47 μ f, R_{BE} is 1 kilo ohm, R_E is 1 kilo ohm and R_L is 100 ohm. Also here we utilized dc power supply i.e. V_{cc} is 12volts. Furthermore we reproduced the circuit by utilizing the MULTISIM 11.0 instrument. The reproduced circuit is indicated in Łgure below.

We mimicked or simulated the circuit. Here we utilized 3 khz square wave info with 10 volts crest to top voltage, and we got the Gaussian pulse yield. At that point we actualized the same circuit with same values on the breadboard, and we accomplished the Gaussian beat basically. In reproduction we got 2 ns length of time Gaussian pulse, however in handy usage we got 13ns term Gaussian pulse (on bread board).

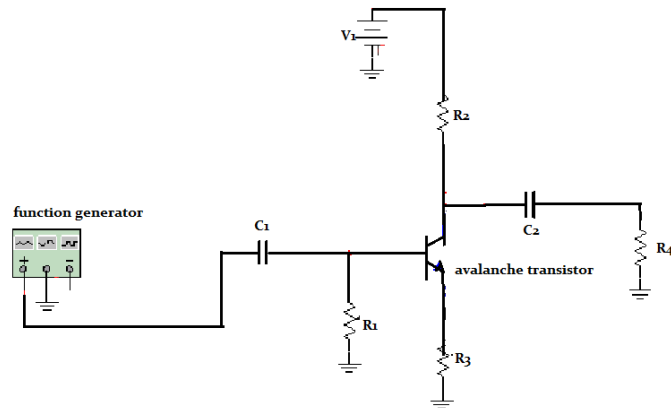


FIG 3.1 UWB pulse Generator using avalanche transistor.[16]

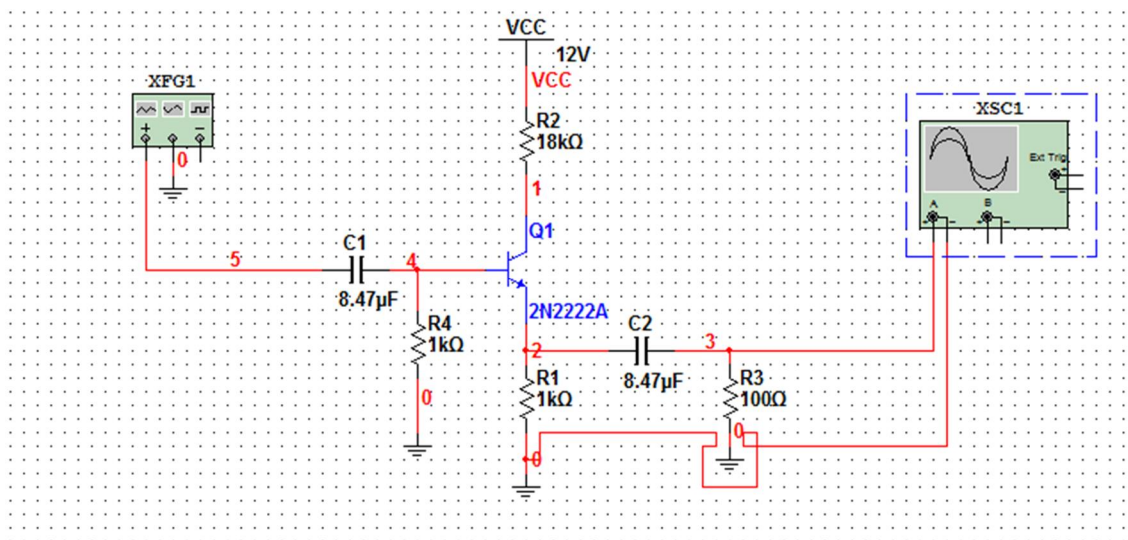
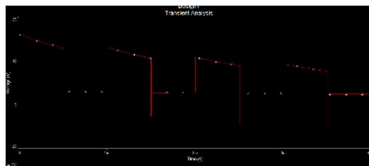


FIG 3.2 circuit is done in MULTISIM



Output in multisim.

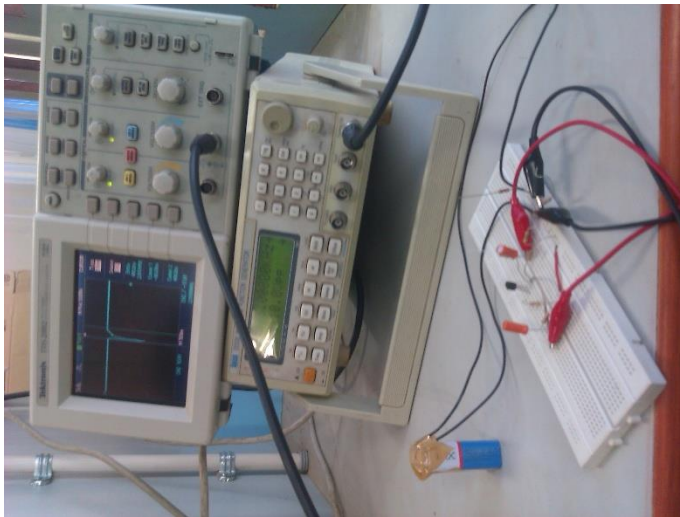
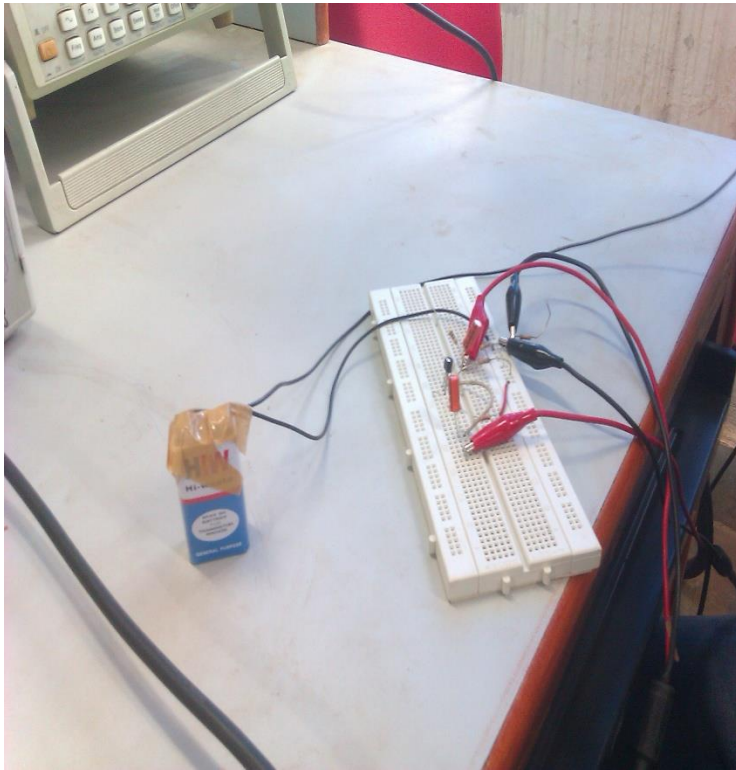


FIG 3.3 implemented in bread board .

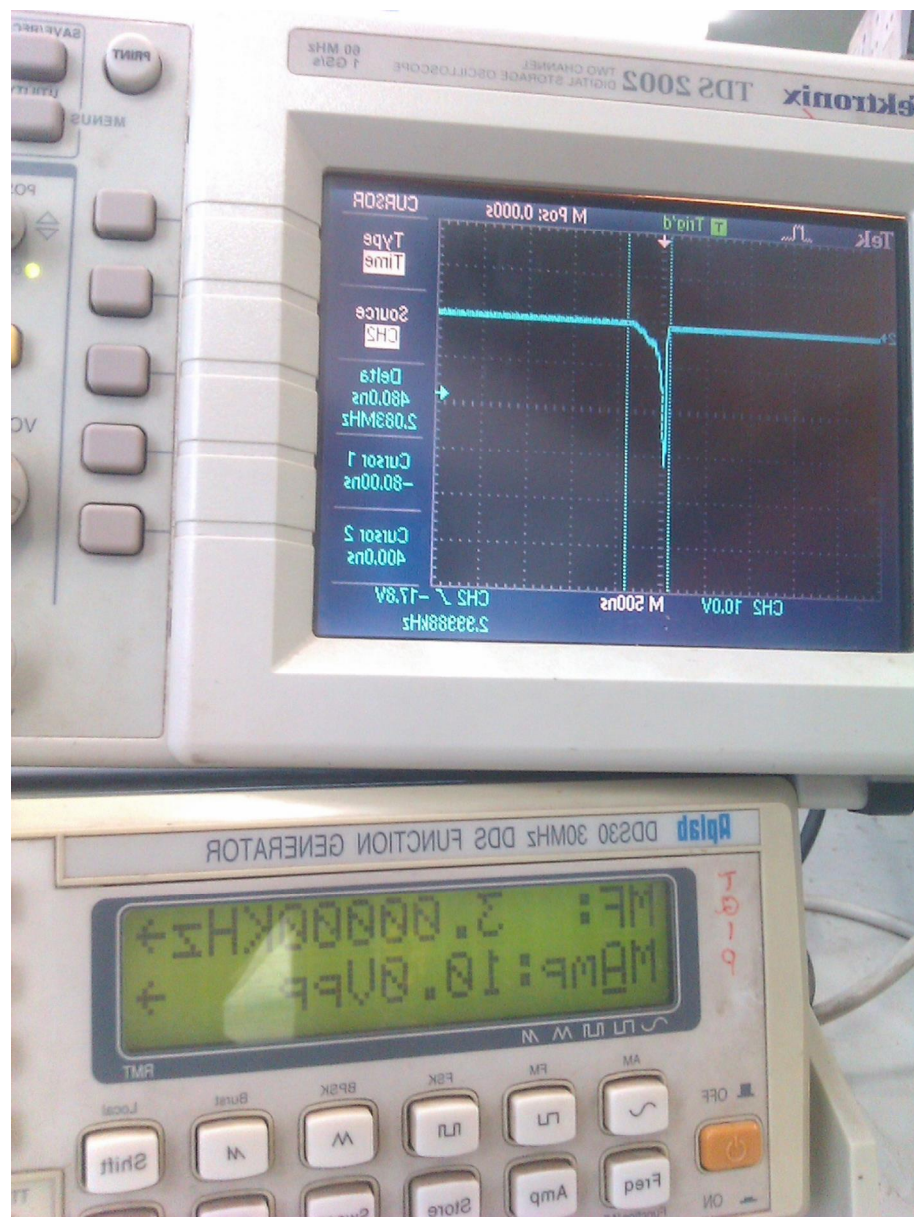




FIG 3. Output of the implemented circuit (upper three figures)

3.3 Conclusion

In this work we introduced a low many-sided quality and low UWB pulse generator building design suitable for UWB GPR requisitions. The circuit gives a Gaussian beat when enacted by a square wave indicator from signal generator. Here we utilized 3 kHz square wave info sign to create Gaussian pulse. The recreated outcomes are given 2ns term Gaussian pulse, however the handy comes about on breadboard given 13ns length of time Gaussian pulse. Here we showed the Gaussian pulse era with lessened ringing levels, and great symmetry.

Chapter 4

Summary and Conclusion

4.1 Summary

In UWB GPR transmitter, one of the most critical function is UWB pulse generation. There are many techniques that are used to generate UWB pulse. This project work implements one simple circuit based on transistor to generate UWB pulse. The circuit is based on avalanche transistor. The circuit was implemented on the breadboard and output waveform was observed on the oscilloscope. The signal generator was used to generate the input signal. The practical result was approximately equal to the simulated result.

4.2 Scope of the future work

There was a marginal difference between the simulated and practical result, a further theoretical analysis can help us to understand this discrepancy. Simulation with other software like : Multisim and P-Spice can help us understand the difference. Simulation with more practical cases might give the comparable result. The results may improve by testing with precise instruments. Proper soldering may also give good results.

4.3 Conclusion

One of the important blocks to realize high resolution GPR is UWB pulse generator. This research work mostly focuses on a pulse generator based on a simple circuit. These circuits are light weight and cost efficient. The UWB spec requirements are not met by the pulse generators. Simulation tools and sophisticated instruments are required for high quality research in UWB pulse generator. Further research to achieve cost efficient and reliable UWB generator will create a huge impact in transforming the present generation of GPR technology.

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